Electrical Conductivity and Viscosity in the System KOH - K_2CO_3 - H_2O

by

M. I. Usanovich and T. I. Sushkevich

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CONDUCTIVITY AND VISCOSITY IN THE SYSTEM

$KOH—K_2CO_3—H_2O$

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The study of electrical conductivity and viscosity of aqueous solutions of KOH containing different quantities of K_2CO_3 was carried out by us with special reference to concentrated solutions of KOH because solutions with such concentrations are used in the industrial electrolysis of water.

The KOH and K_2CO_3 used in this work were manufactured by the firm of Kahlbaum. The solutions were prepared with water twice distilled with $KMnO_4$ and $Ba(OH)_2$, the conductivity of which ranged from 0.8 to $1.5 \cdot 10^{-5}$ Ω^{-1}. In preparing the solution, the caustic alkali was first washed several times in the bidistillate in order to destroy the surface crust of carbonate, since we were interested in the effect of K_2CO_3 on the conductivity and we wanted to begin with solutions containing the largest possible amount of K_2CO_3. The solutions thus prepared contained from 0.3 to 0.5 percent of potassium carbonate. The determination of conductivity was made at three temperatures: 25, 50 and 97 degrees centigrade. (97 degrees was the boiling point for water under the experimental conditions). The conductivity measurements were made in the interval between 18.86 and 41.59 percent of KOH with contents of potassium carbonate from 1 to 31 percent.

The results of the conductivity measurements are collected in Tables 1-7.

Table 1

CONDUCTIVITY VALUES WITH AN 18.68 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	κ 25°	κ 50°	κ 97°
1	--	0.6042	0.8769	1.4143
2	2.00	0.5893	0.8588	1.3815
3	9.76	0.5289	0.7864	1.2759
4	21.50	0.4329	0.6612	1.1304
5	25.97	0.3933	0.6134	1.0510

Table 2

CONDUCTIVITY VALUES WITH A 21.95 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	κ 25°	κ 50°	κ 97°
1	--	0.6527	0.9637	1.5506
2	3.54	0.6225	0.9240	1.3880
3	6.26	0.5959	0.8912	1.4456
4	14.20	0.5233	0.7959	1.3329
5	18.20	0.4789	0.7452	1.2590
6	31.10	0.3457	0.5708	1.0420

On the basis of the data obtained, it was established that the increase of the potassium carbonate percentage in the alkali lowers the specific conductivity of the solution.

Table 3

CONDUCTIVITY VALUES WITH A 26.37 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	χ 25°	χ 50°	χ 97°
1	--	0.6753	1.0190	1.6741
2	2.55	0.6460	0.9831	1.6300
3	7.19	0.6016	0.9156	1.5398
4	13.40	0.5275	0.8199	1.4176
5	30.87	0.3291	0.5665	1.0501

Table 4

CONDUCTIVITY VALUES WITH A 28.58 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	χ 25°	χ 50°	χ 97°
1	--	0.6694	1.0072	1.7042
2	2.41	0.6395	0.9689	1.6475
3	8.14	0.5693	0.8806	1.5176
4	14.60	0.5089	0.8013	1.3980
5	21.30	0.4115	0.6709	1.2120

Table 5

CONDUCTIVITY VALUES WITH A 31.45 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	κ 25°	κ 50°	κ 97°
1	--	0.6660	1.0185	1.7625
2	2.81	0.6308	0.9735	1.7055
3	9.20	0.5505	0.8635	1.5473
4	11.47	0.5244	0.8340	1.4926
5	19.35	0.4294	0.7032	1.3092

Table 6

CONDUCTIVITY VALUES WITH A 33.72 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	κ 25°	κ 50°	κ 97°
1	--	0.6499	1.0093	1.7262
2	1.05	0.6340	1.0082	1.6692
3	2.08	0.6289	0.9927	1.6198
4	2.97	0.6127	0.9604	1.5479
5	9.98	0.5113	0.8629	1.5258
6	23.5	0.3611	0.6217	1.2123

Table 7

CONDUCTIVITY VALUES WITH A 41.59 PERCENT CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	χ 25°	χ 50°	χ 97°
1	--	0.5596	0.9305	1.7315
2	3.02	0.5237	0.8807	1.6601
3	7.00	0.4702	0.8023	1.5450
4	11.47	0.4164	0.7258	1.4169
5	12.50	0.3994	0.6998	1.3840

At first sight this fact is astonishing. It would seem that by adding one electrolyte to another with which it does not react chemically should lead to an increase in the conductivity of the solution. However we observed this opposite. The only possible explanation is that the drop in conductivity is a consequence of the increase in the viscosity of the solution, while the relative increase in the viscosity after addition of K_2CO_3, exceeds the increase in the concentration of ions. In order to test this theory we studied the viscosity of the same solutions at two initial concentrations of KOH.

The measurements were made at temperatures of 25 and 50 degrees centigrade. The results of the measurements are gathered in Tables 8 and 9.

Table 8

VISCOSITY AT A 28.58 PERCENT

CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	$\chi_{25°}$	$\chi_{25°}$	$\chi_{50°}$	$\chi_{50°}$
1	--	2.0975	1.2791	1.2955	1.2644
2	2.41	2.2230	1.2947	1.3570	1.2807
3	8.14	2.5916	1.3309	1.5685	1.3177
4	14.6	3.0946	1.3689	1.8229	1.3520
5	21.3	4.1209	1.4243	2.3554	1.4112

Table

VISCOSITY AT A 31.45 PERCENT

CONCENTRATION OF KOH

No	Amount K_2CO_3 (in Percent)	$\chi_{25°}$	$\chi_{25°}$	$\chi_{50°}$	$\chi_{50°}$
1	--	2.2786	1.3080	1.3953	1.2964
2	2.81	2.5163	1.3247	1.5254	1.3103
3	9.20	3.0707	1.3669	1.8108	1.3449
4	19.35	4.1197	1.4270	2.3506	1.4139

As may be seen from Tables 8 and 9, the viscosity of the KOH solution grows with the increase of K_2CO_3 concentration. Upon correcting the conductivity according to the viscosity, the character of the conductivity variation changed abruptly.

With an increase of the K_2CO_3 concentration, the values of the corrected conductivity grow monotonously. This growth shows that the drop in the KOH solution conductivity after an increase of K_2CO_3 concentration actually occurs because of an increase in the solution's viscosity.

CONCLUSIONS

1) We examined the conductivity of solutions with KOH concentrations from 18.86 to 41.59 percent and a content of potassium carbonate from 1 to 31 percent. We carried out the experiments at temperatures of 25, 50 and 97 degrees centigrade. We established that the specific conductivity of a KOH solution diminishes with addition of K_2CO_3.

2) We examined the viscosity for two KOH concentrations with different K_2CO_3 content, at temperatures of 25 and 50 degrees centigrade. The viscosity of the KOH solution increases with the addition of K_2CO_3. The drop of the specific conductivity of the solution occurs as a consequence of its increased viscosity.

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